

ART 24 ADAPT

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Claims

1. A rate adaptive pacemaker comprising a means (2) for
 5 determining the demand of a patient's organism, a pacing
 rate controlling means (16) for controlling the pacing rate
 in response to the patient's demand, and a pacing rate
 limiting means (14) for preventing the pacing rate from
 becoming too high, said pacing rate limiting means (14)
 10 being adapted to limit the pacing rate upwards such that a
 predetermined relation is maintained between energy supplied
 to the myocardium and energy consumed by the myocardium, and
 including an upper limit setting means (12) for setting an
 upper limit value for the pacing rate, and an upper limit
 15 determining means (10) for determining the relation between
 energy supplied to the myocardium and energy consumed by the
 myocardium for calculating an upper pacing rate limit value
 from said relation for supply to said upper limit setting
 means (12), characterized in that said pacing rate limiting
 20 means (14) is adapted to limit the pacing rate upwards such
 that the energy consumed by the myocardium always is less
 than energy supplied to the myocardium.

2. The pacemaker according to claim 1, characterized in
 25 that said pacing rate limiting means is adapted to limit the
 pacing rate such that the inequality

$$(t_{diast,rest}/t_{diast}) \cdot (SV/SV_{rest}) < CR$$

is satisfied, where $t_{diastrest}$ denotes diastolic duration for
 30 the patient in rest conditions, t_{diast} actual diastolic
 duration for the patient, SV and SV_{rest} actual stroke volume
 and stroke volume for the patient in rest conditions
 respectively, and CR the coronary reserve.

35 3. The pacemaker according to claim 1 or 2, characterized
 in that said upper limit determining means (10) includes an
 energy determining means for determining the energy supplied

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to the myocardium and the energy consumed by the myocardium respectively, and a comparison means for comparing supplied energy and consumed energy for determining said relation.

5 4. The pacemaker according to claim 3, **characterized in** that said energy determining means is adapted to determine consumed energy as the product of mean value of ventricular pressure variations during a cardiac cycle and stroke volume.

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5. The pacemaker according to claims 3 or 4, **characterized in** that said energy determining means is adapted to determine supplied energy from the time response curve of the arterial pressure during diastole.

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6. The pacemaker according to claim 5, **characterized in** that said upper limit determining means (10) is adapted to determine actual coronary resistance ratio (CRR) from the equation

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$$\text{supplied energy} = \text{consumed energy}$$

and determine an upper pacing rate limit value from the relation between actual coronary resistance ratio (CRR) and coronary reserve (CR).

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7. The pacemaker according to any of the claims 1-6, **characterized in** that said upper limit determining means is adapted to determine the upper pacing rate limit value from the equation

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$$\text{upper pacing rate limit} = (60 \cdot \text{CR}) / [t_{\text{diast, rest}} \cdot (\text{SV} / \text{SV}_{\text{rest}}) + \text{CR} \cdot t_{\text{syst}}]$$

where CR denotes the coronary reserve, $t_{\text{diastrest}}$ diastolic duration for the patient in rest conditions, SV and SV_{rest} actual stroke volume and stroke volume for the patient in rest conditions respectively, and t_{syst} the actual systolic duration.

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8. The pacemaker according to any of the claims 2-7, **characterized in** that a bioimpedance measurement unit is

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provided to measure the intracardiac bioimpedance as a function of time and determine therefrom actual stroke volume SV and actual diastolic or systolic durations t_{diast} or t_{syst} respectively.

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9. The pacemaker according to any of the claims 2-7, characterized in that an ECG measuring and analyzing unit is provided to measure ECG and determine therefrom actual stroke volume SV and actual diastolic or systolic durations t_{diast} or t_{syst} respectively.
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Add #2

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